The Forte Framework for Music Composition

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Lambda Days 2015

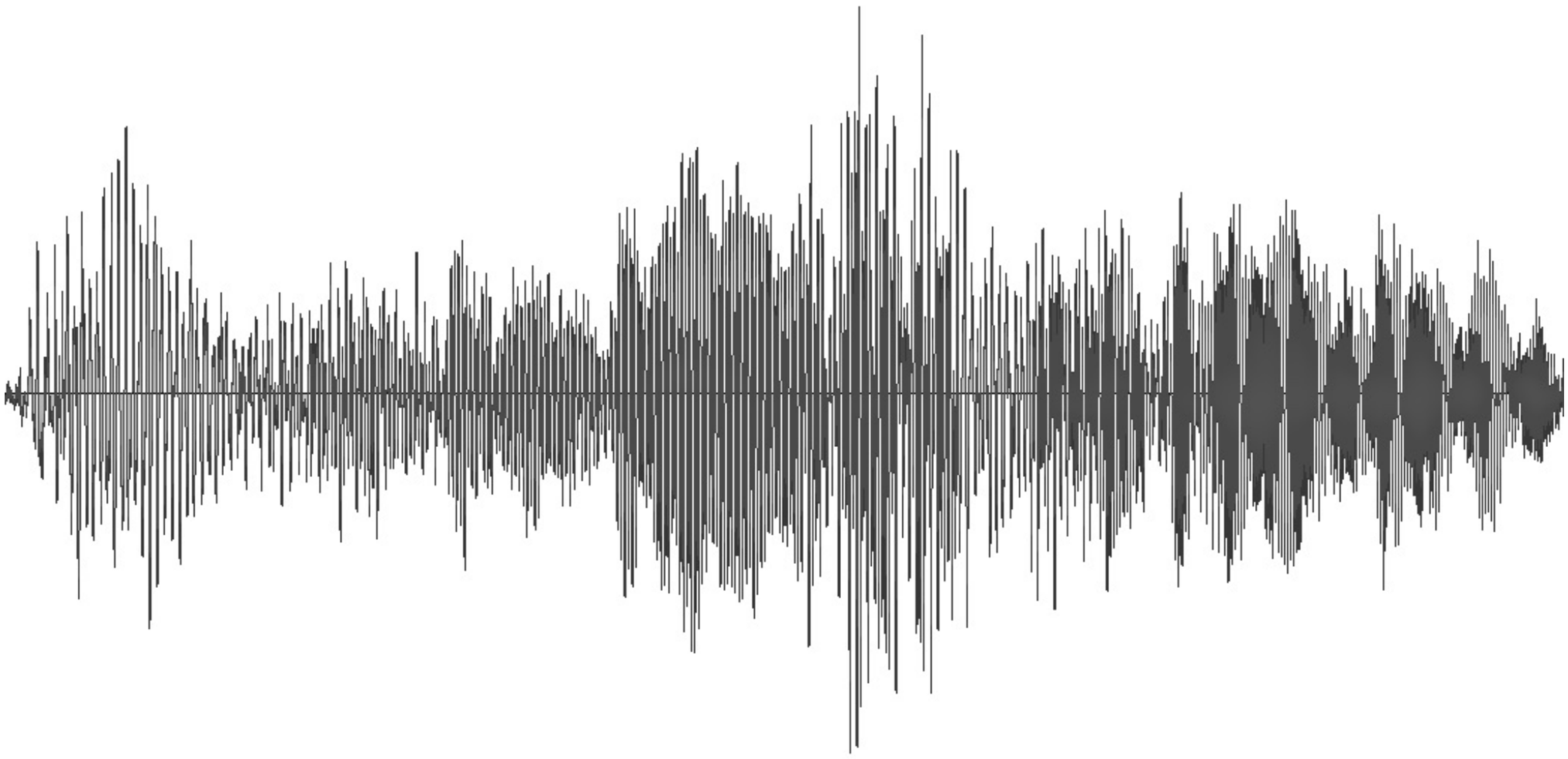
„Now art is the contrary of chaos.”

– Igor Stravinsky

The Problem

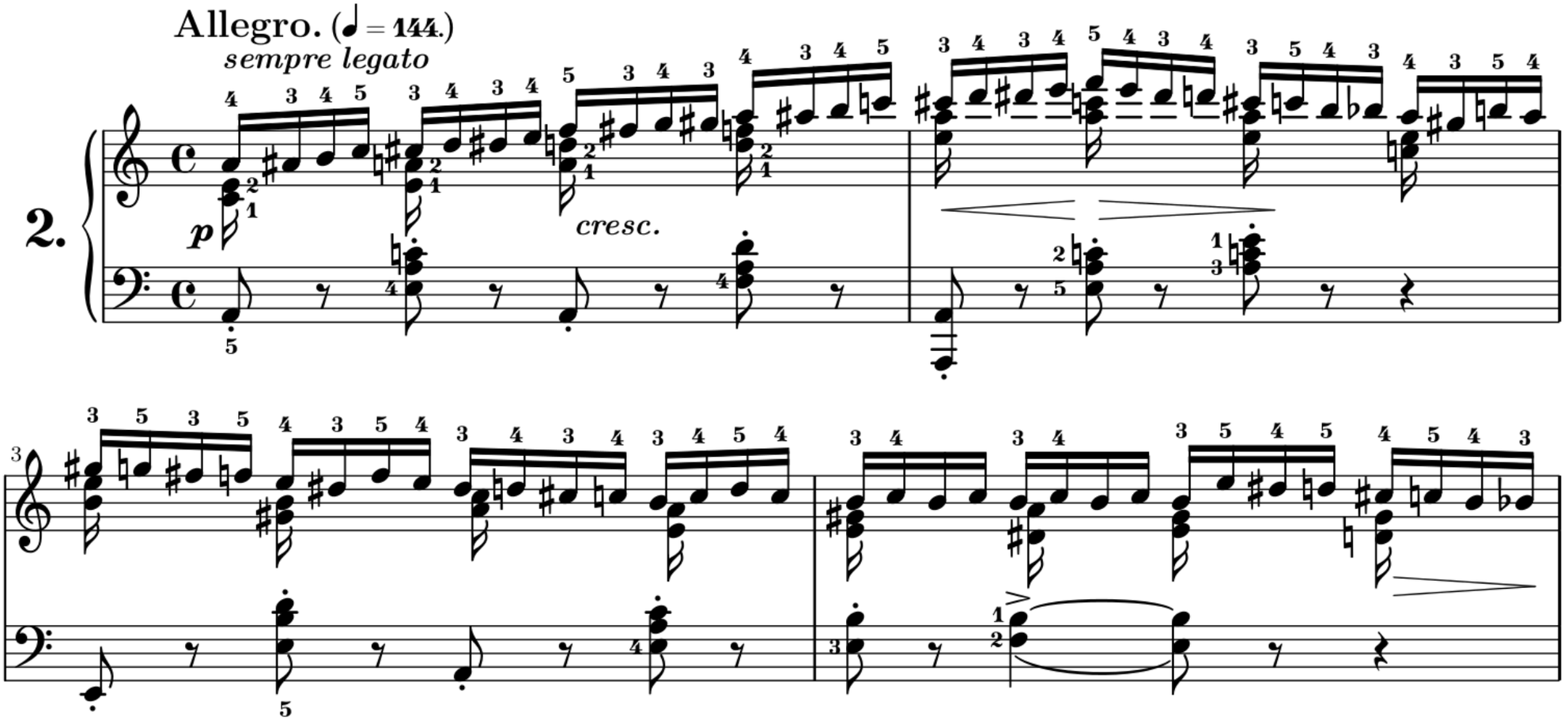
Frederic Chopin playing for prince Radziwiłł in 1887,
Henryk Siemiradzki

How to grasp music?



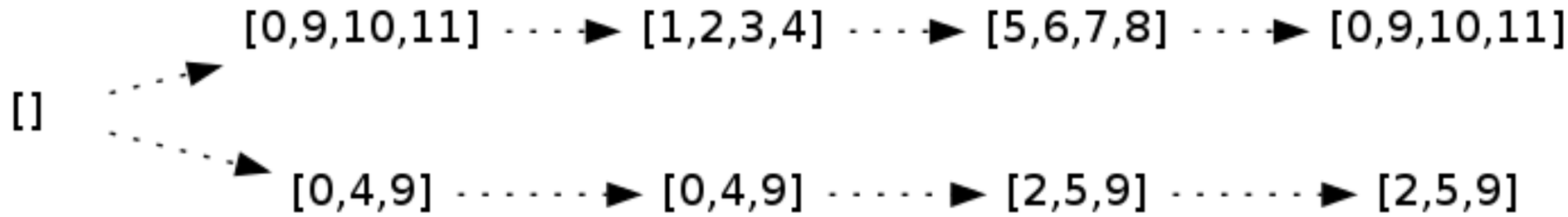
"Etude in A minor" (Op. 10, No. 2) by Fryderyk Chopin

A partial solution



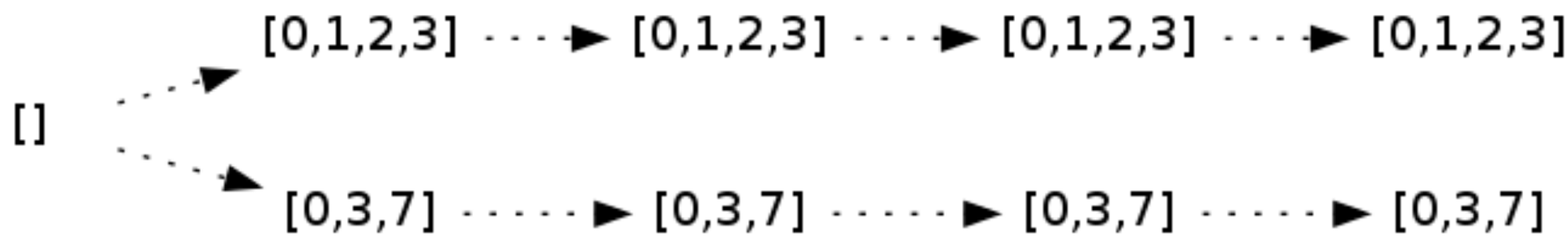
"Etude in A minor" (Op. 10, No. 2) by Fryderyk Chopin

What we would like instead?



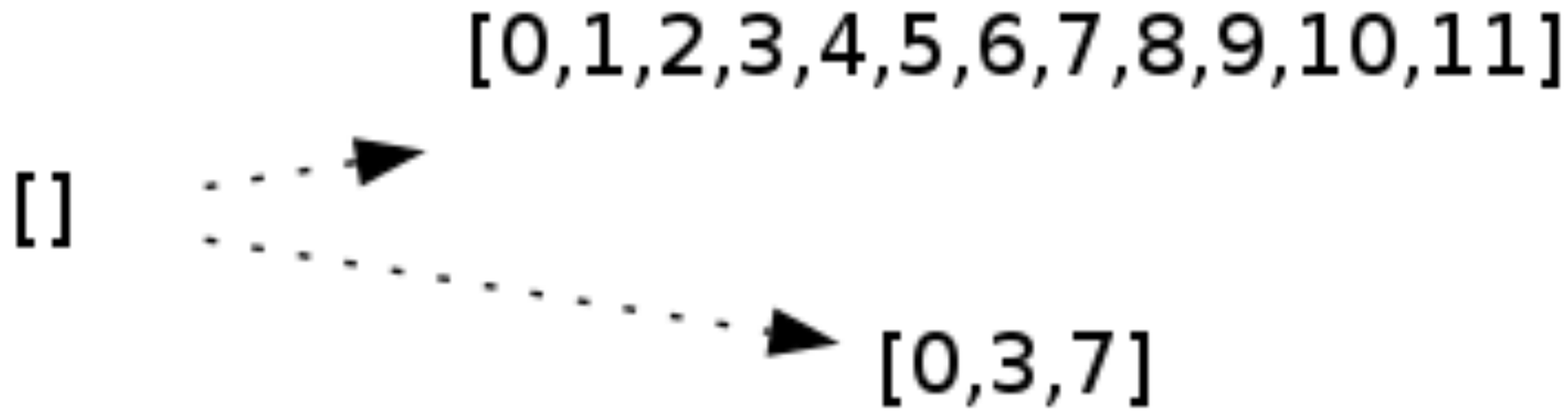
"Etude in A minor" (Op. 10, No. 2) by Fryderyk Chopin

Even better …



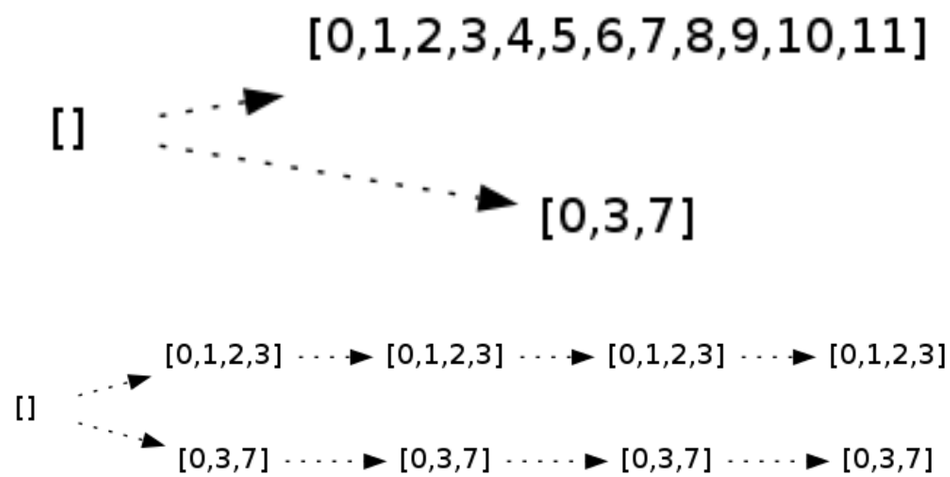
"Etude in A minor" (Op. 10, No. 2) by Fryderyk Chopin

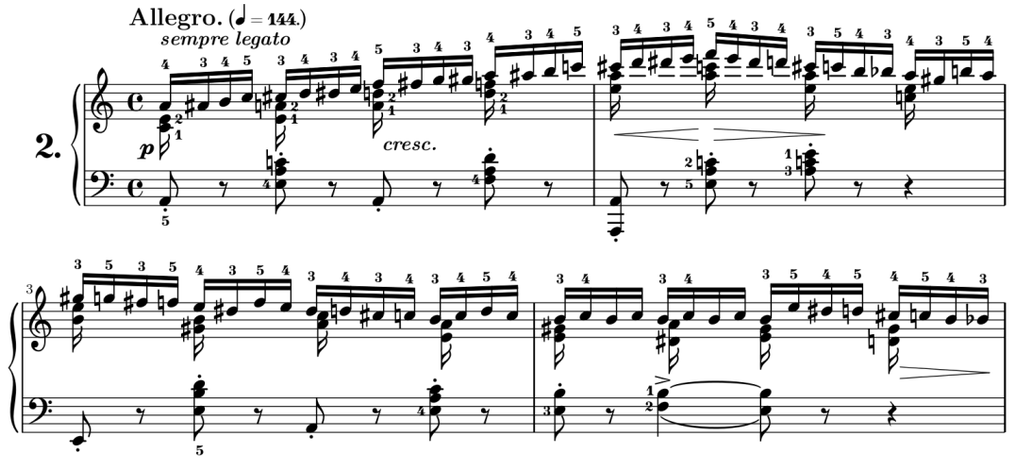
Wow!

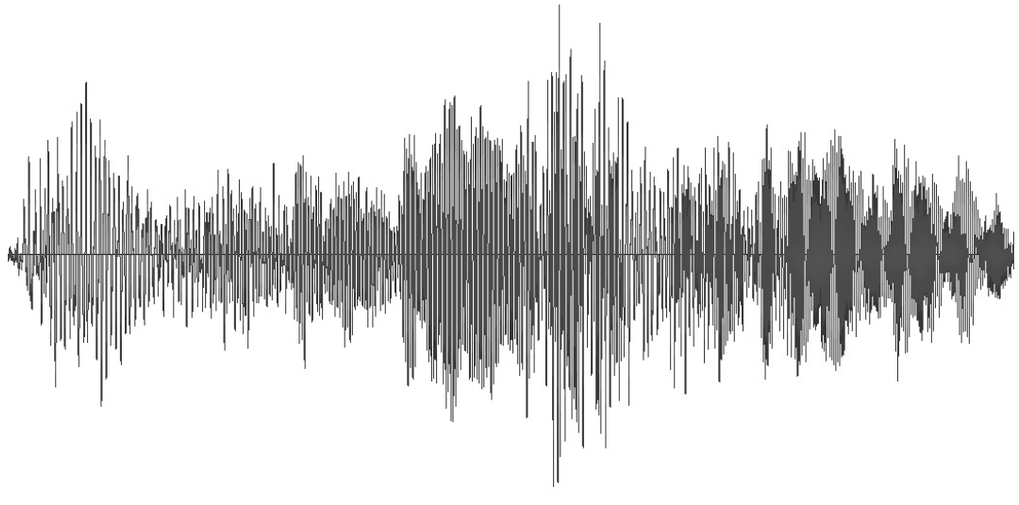


"Etude in A minor" (Op. 10, No. 2) by Fryderyk Chopin

Structure Theory







fORTE

Forte DSL

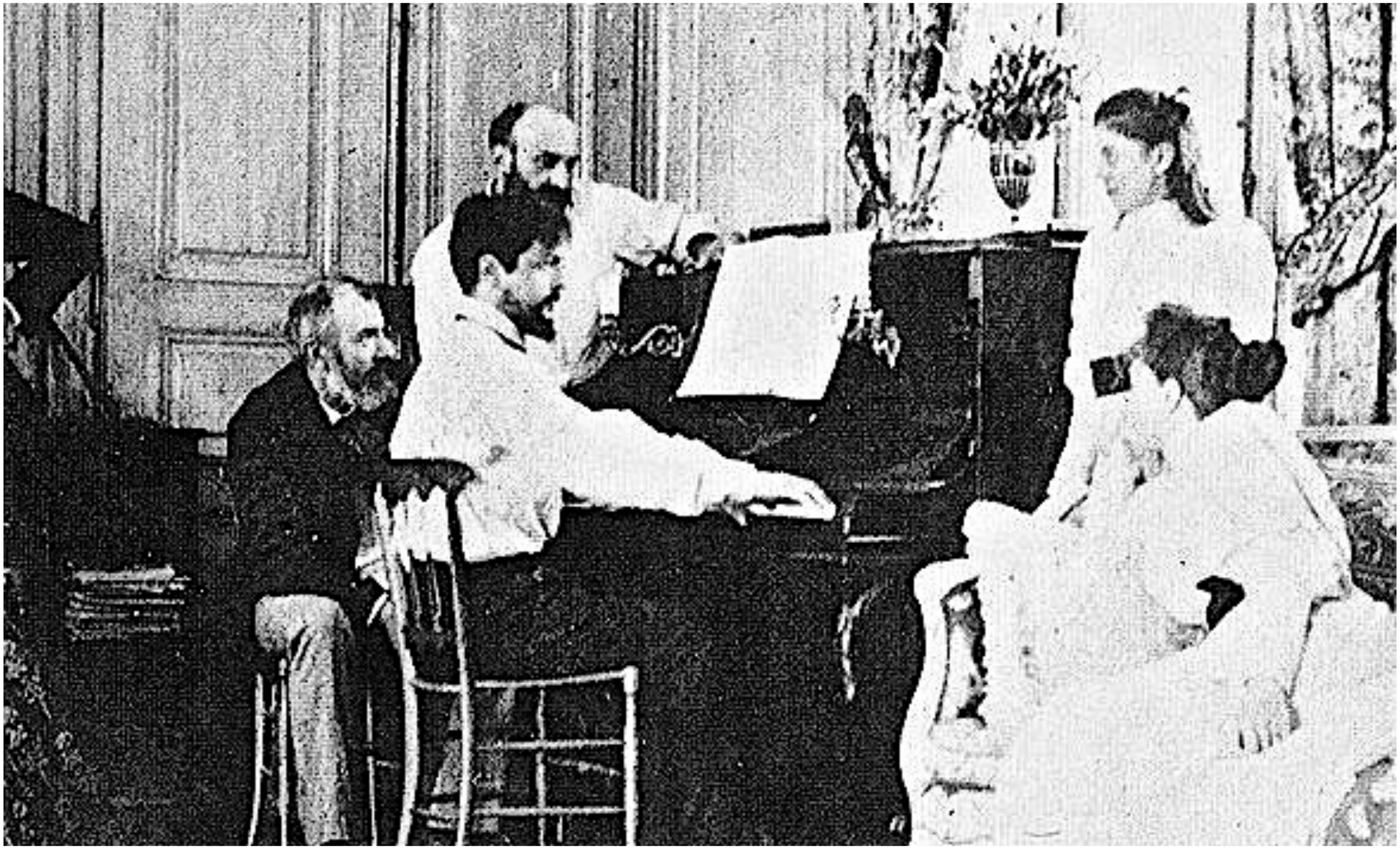
Forte DSL

Allen Forte (born December 23, 1926) is a music theoretician and musicologist best known for his work “The Structure of Atonal Music” published by Yale University Press.

What is Forte theory?

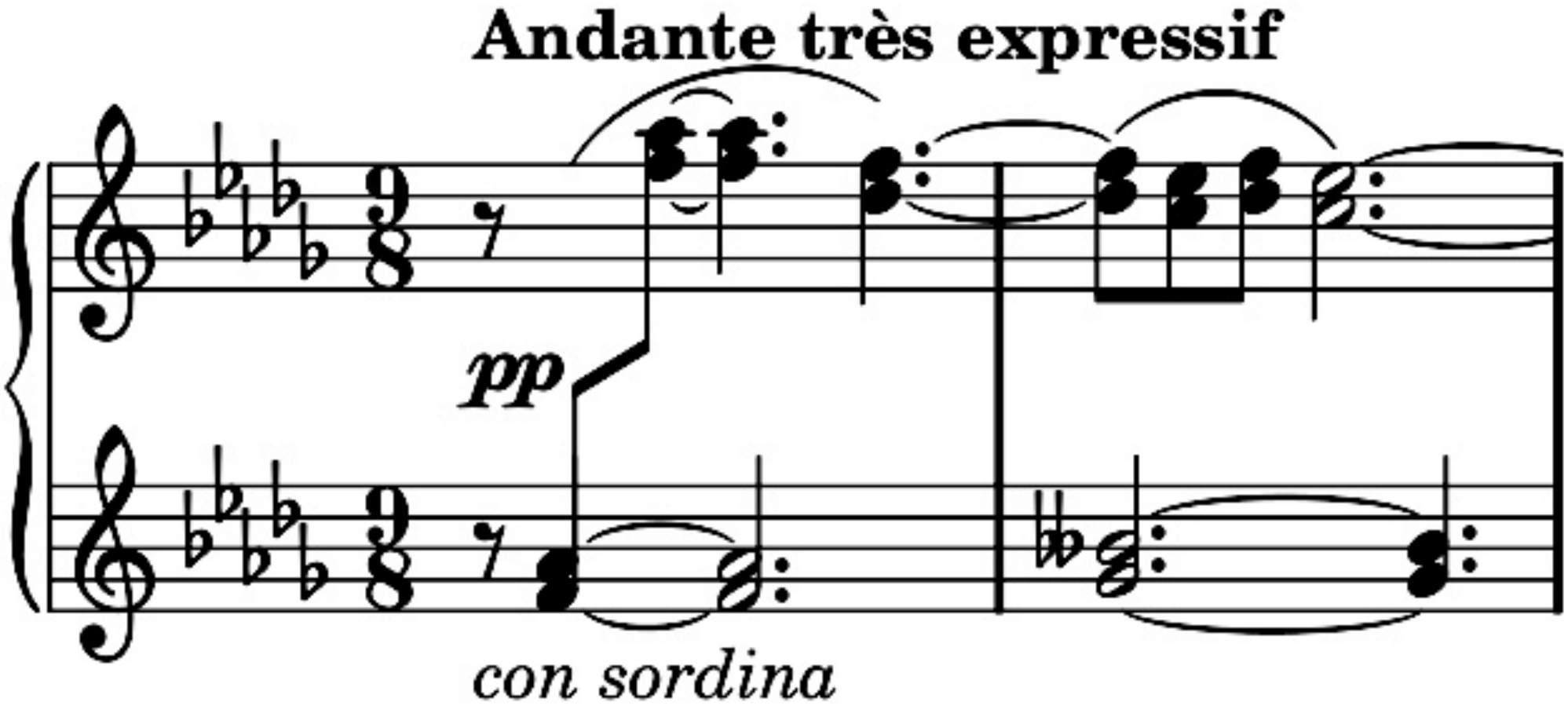
- A mapping of pitches to pitch classes
- A mapping of intervals to interval classes
- A grouping of pitch classes with pitch class sets
- Pitch class set normalization
- Various pitch class set relations
- Analysis with interval vectors and basic interval patterns
- Complexes and subcomplexes

Mapping music to numbers



Claude Debussy at the piano

Pitches to Pitch Class Sets



=

[0,3,7] - - - ▶ [0,3,6,9]

Forte mapping - "Clair de lune" C. Debussy

Contributions

What we propose:

- Forte theory systematization and enhancement
- A EDSL instead of a batch processor for manipulating
- Forte-theoretic entities
- Techniques for domain abstraction, interpretation swapping and self-optimizing library implementation
- A method for boilerplate code reduction

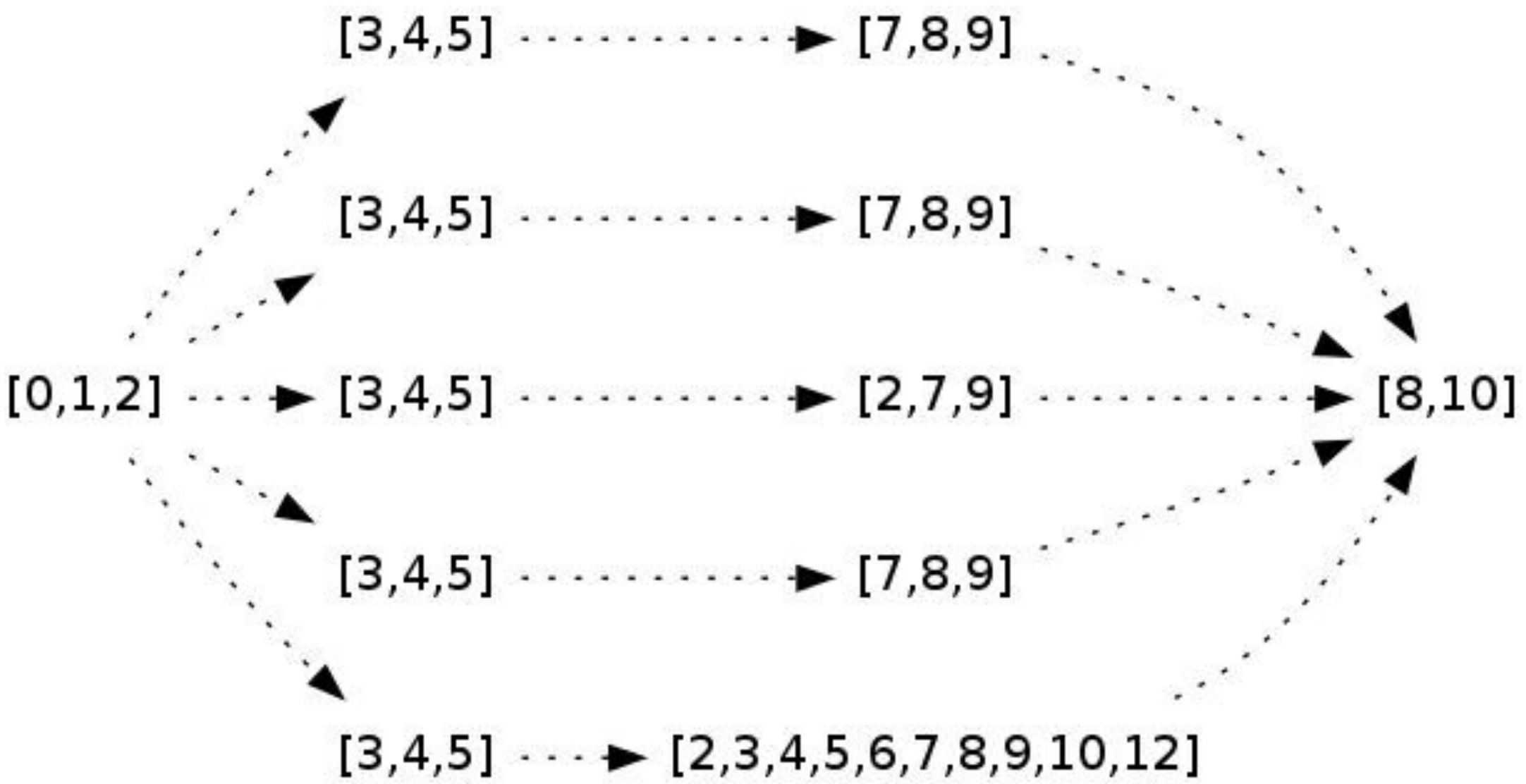
Graph DSL

Graph DSL

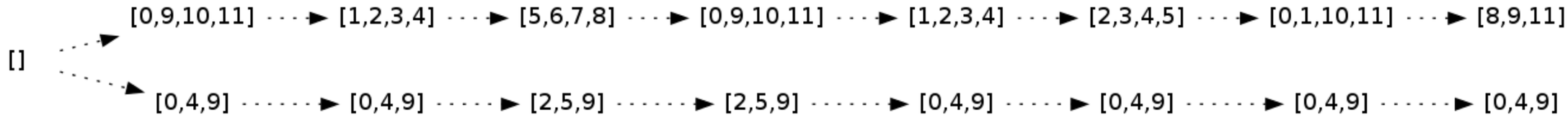
Basic concepts:

- Modeling music as a graph
- Time axis and musical time windows
- Vertical plane
- Musical paths and the horizontal plane

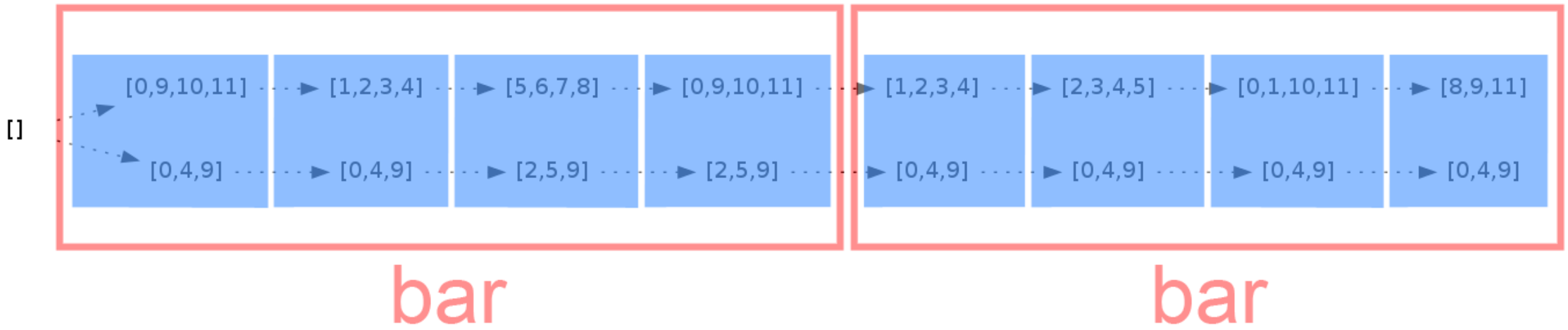
Graph DSL example



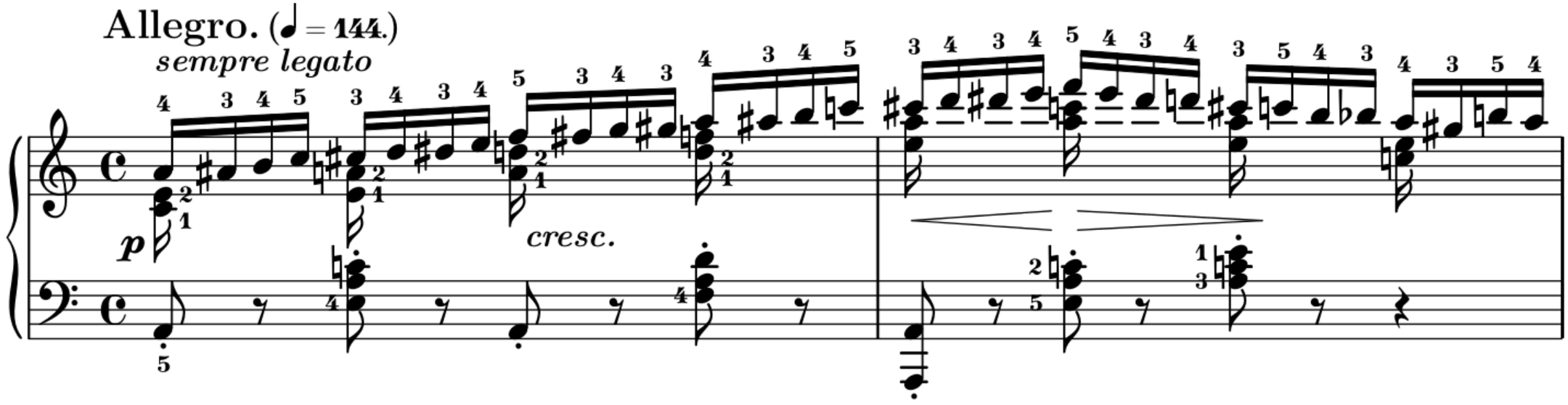
Musical Time Window



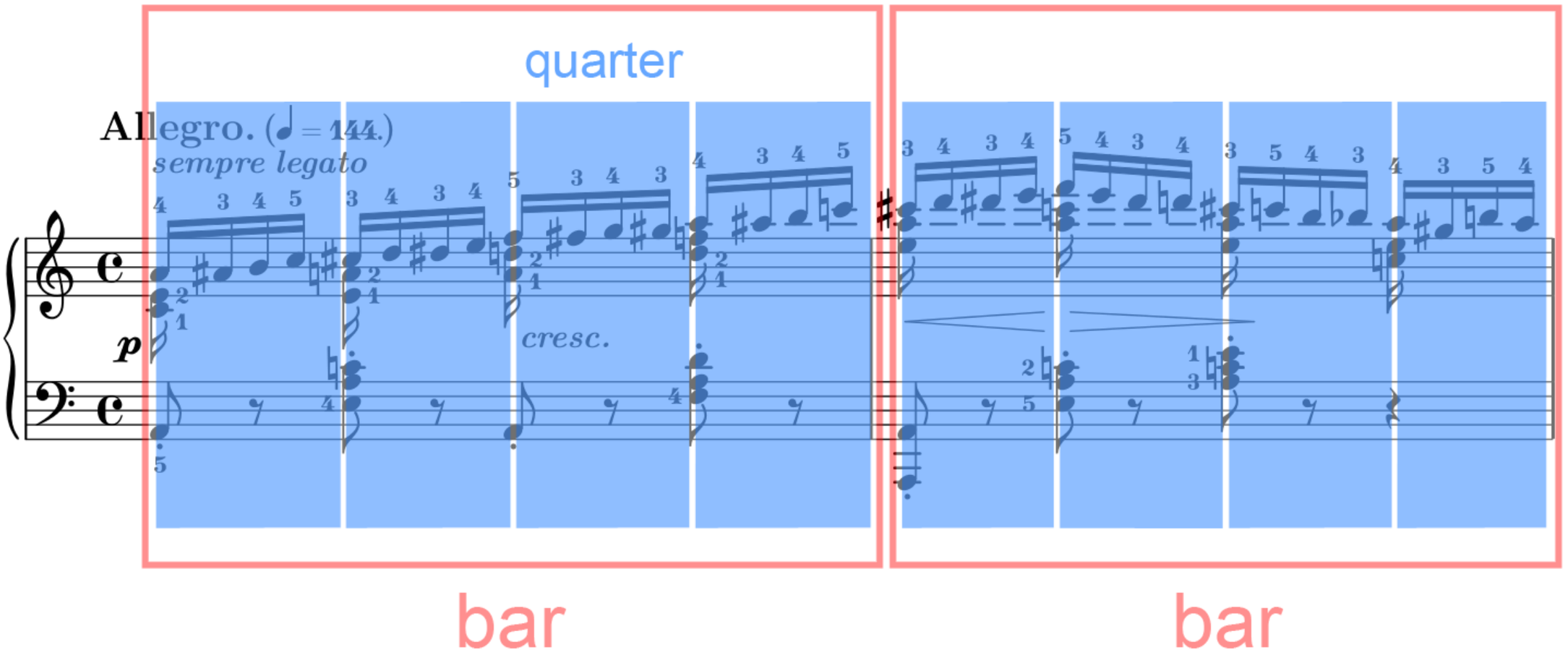
Musical Time Window



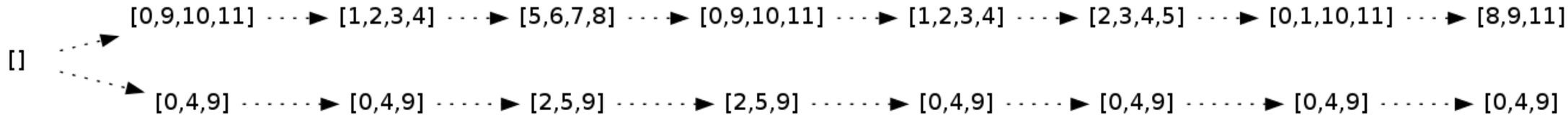
Musical Time Window



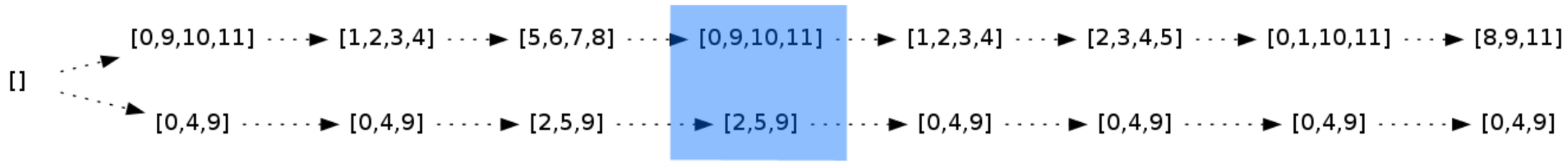
Musical Time Window



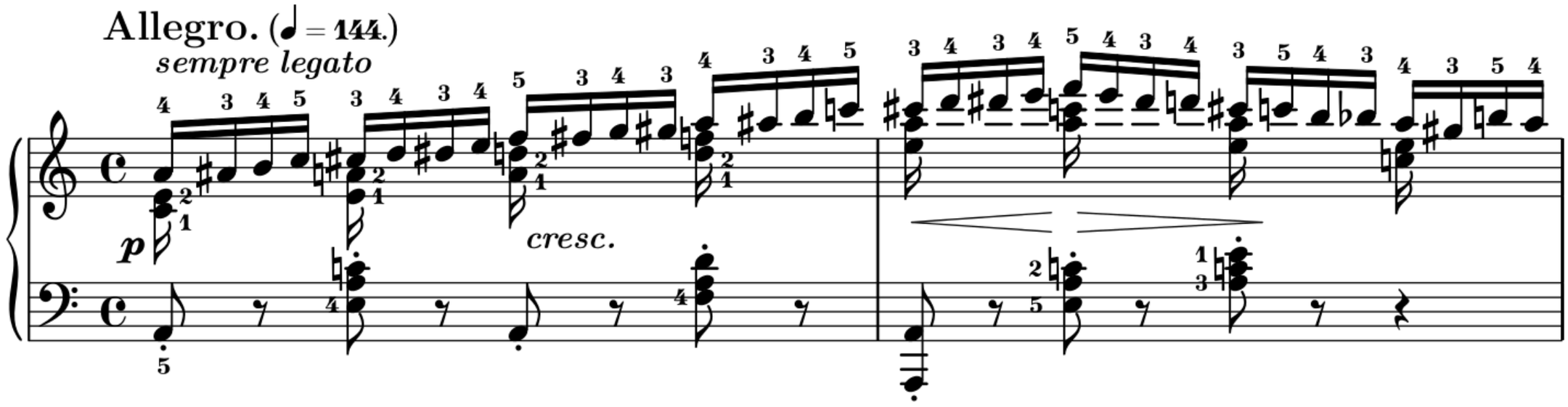
Vertical Plane



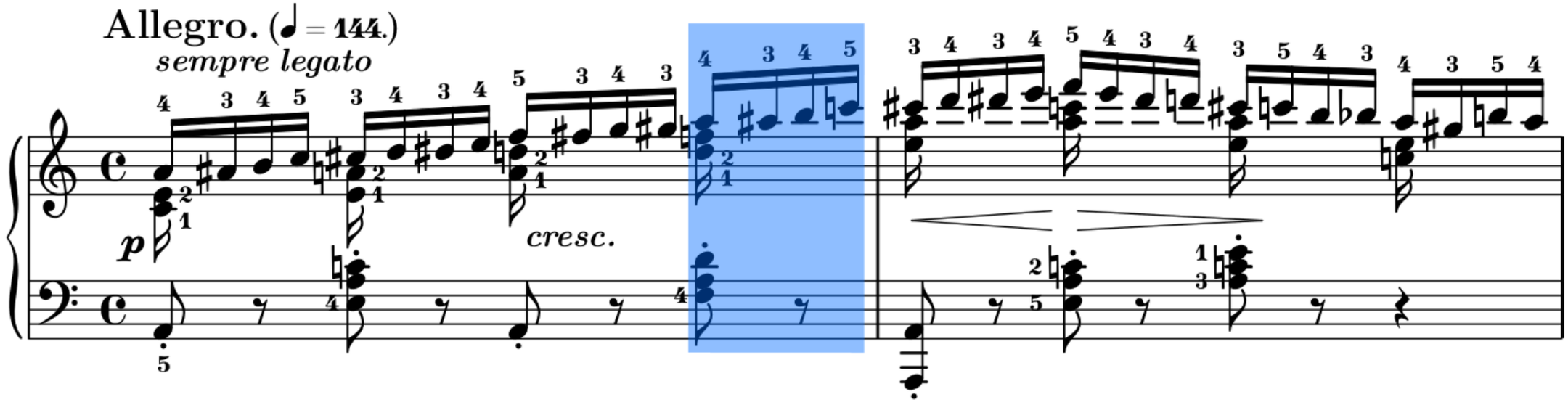
Vertical Plane



Vertical Plane

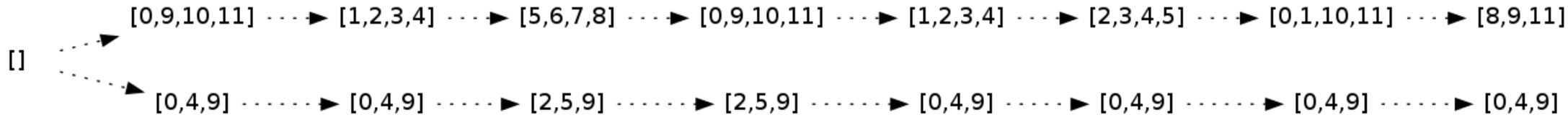


Vertical Plane

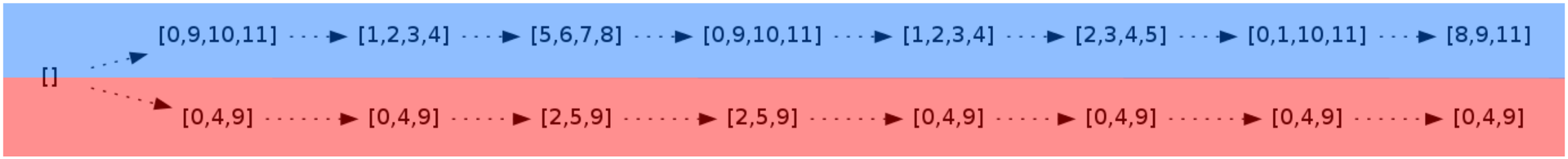


Quarter Note Time Window

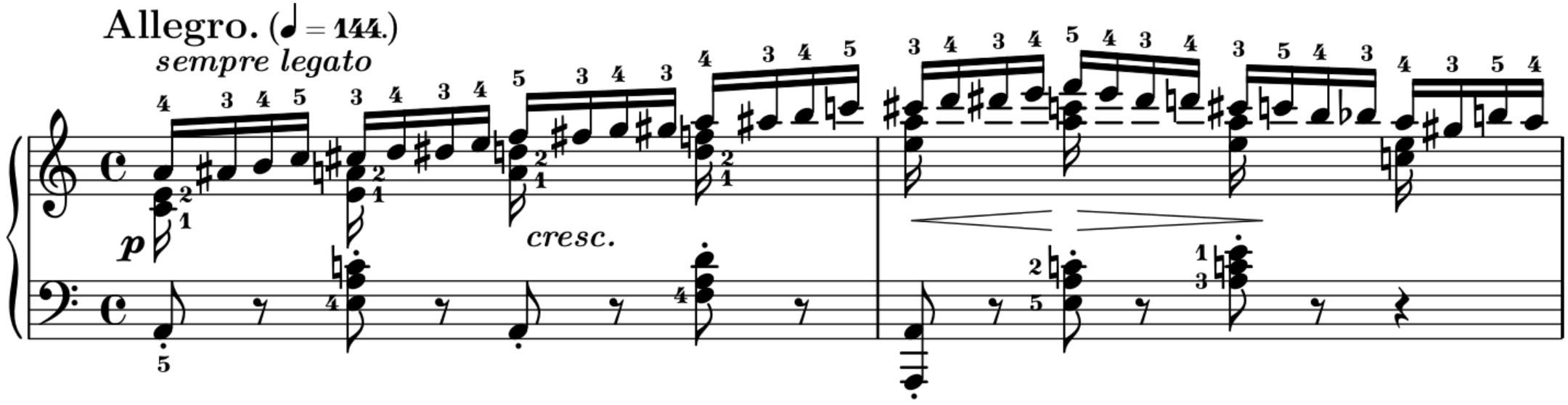
Horizontal Plane



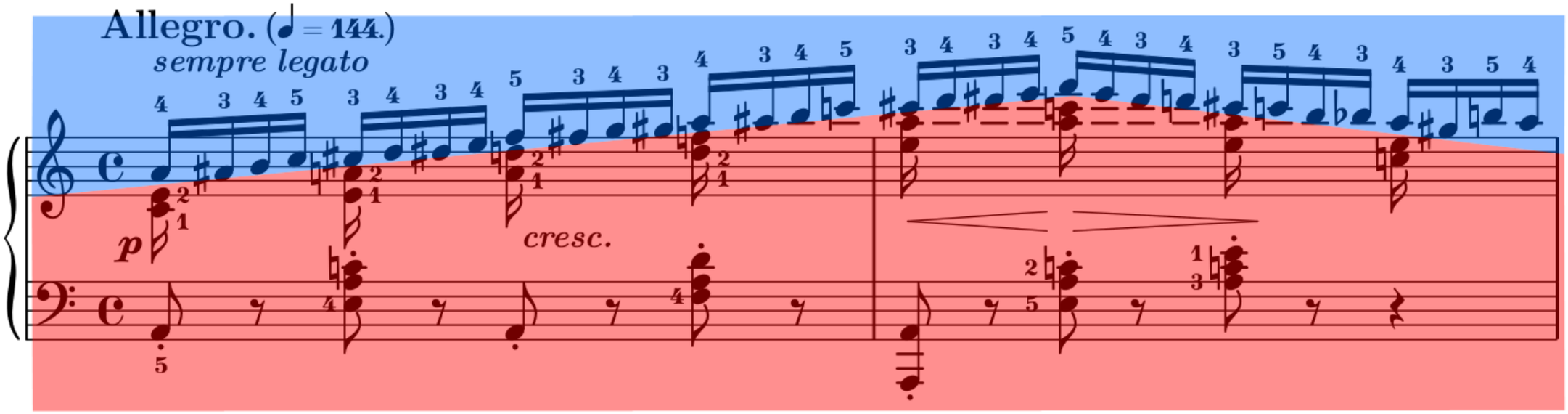
Horizontal Plane



Horizontal Plane



Horizontal Plane



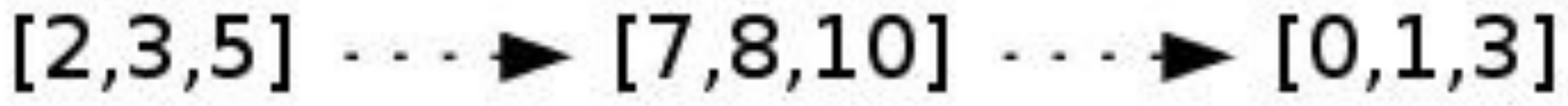
Two Horizontal Planes

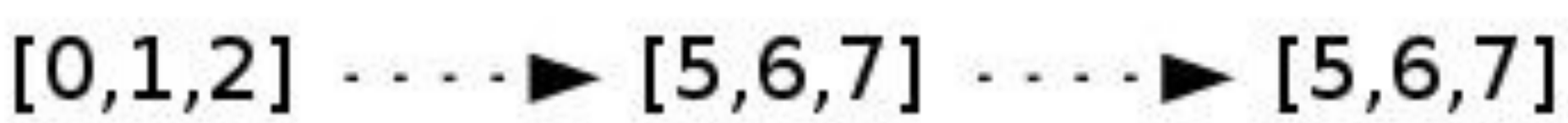
Graph DSL operations

Function application code example

```
forte [pcs [0, 1, 2], pcs [2, 3, 5]] $
    init
$=: transpose 5
$=| [2] |= primeForm
```

Function Application Intuition

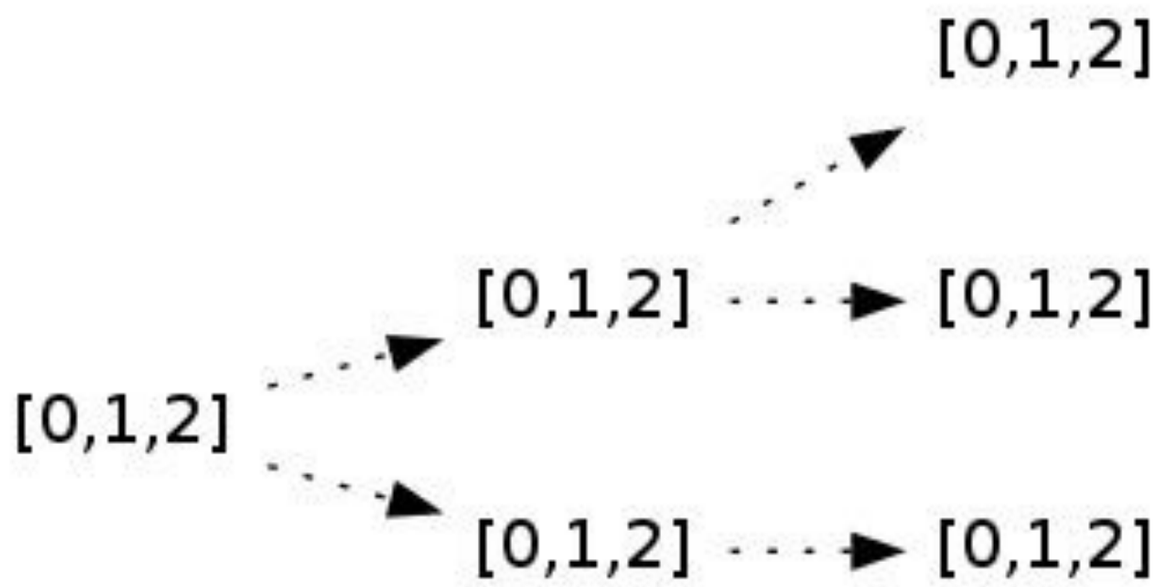




Split code example

$$
\begin{aligned}
&\mathit{forte}\ [\mathit{pcs}\ [0,1,2],\ \mathit{pcs}\ [2,3,5]]\ \$ \\
&\quad \mathit{init} \\
&\$ <: 2 \\
&\$ <|\ [1,3]\ |< 2
\end{aligned}
$$

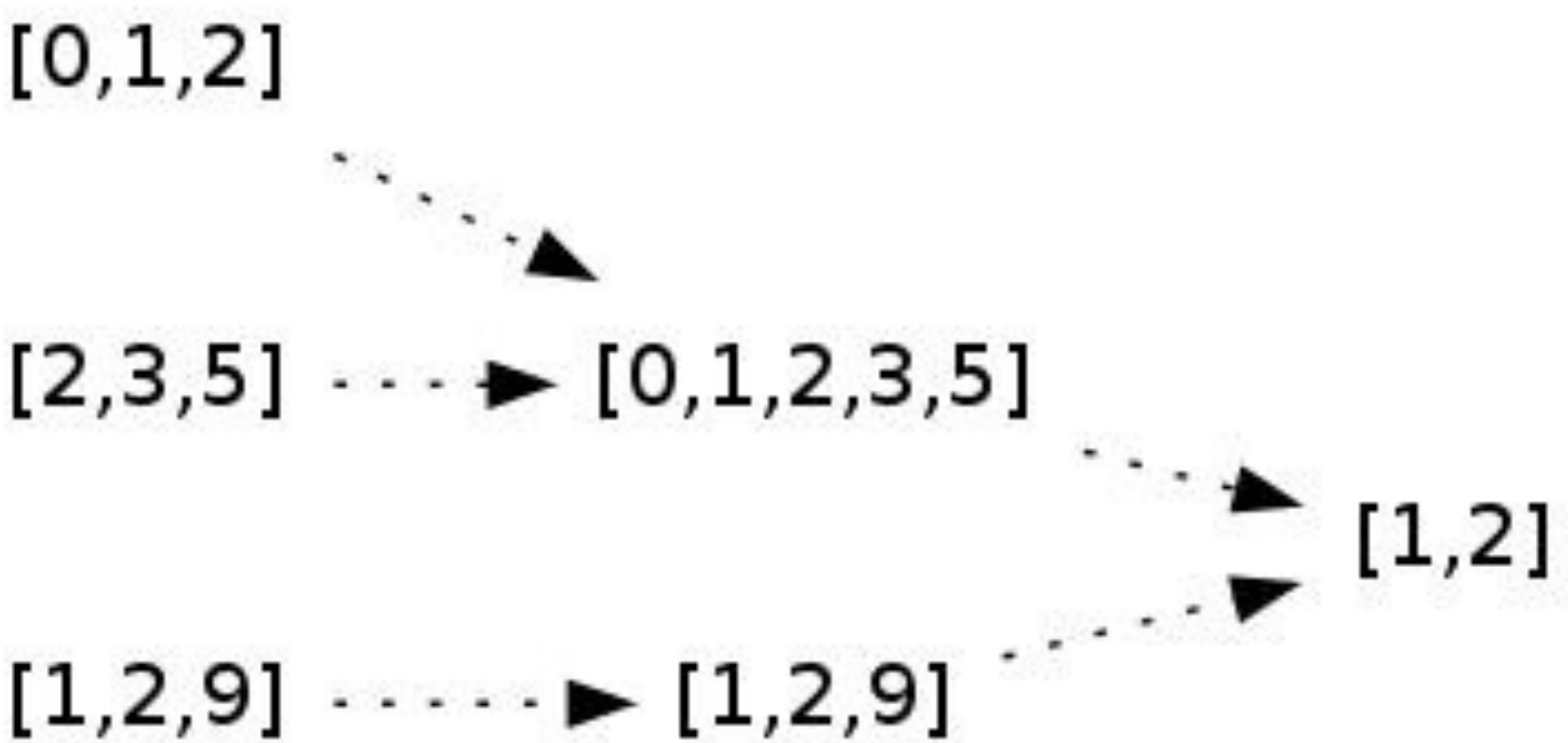
Split intuition



Merge code example

```
forte [pcs [0, 1, 2], pcs [2, 3, 5], pcs [1, 2, 9]] $
    init
$>| [1, 2] |> unify
$>: intersect
```

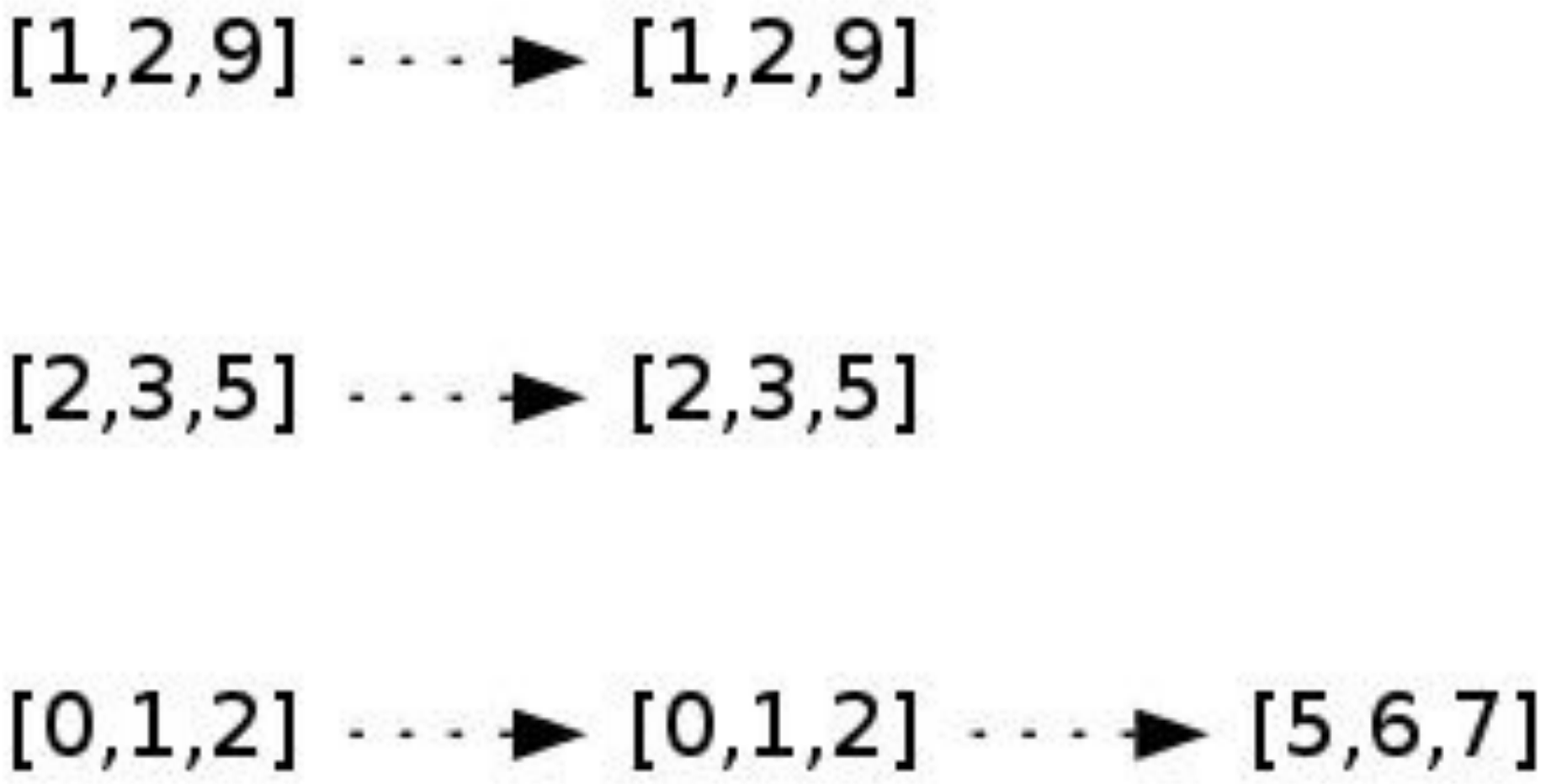
Merge Intuition



Cut and Inject code example

$$
\begin{aligned}
&\mathit{forte}\ [\mathit{pcs}\ [0,1,2],\ \mathit{pcs}\ [2,3,5],\ \mathit{pcs}\ [1,2,9]]\ \$\\
&\quad \mathit{init}\\
&\quad \$ >> 1\\
&\quad -|\ [2..]\\
&\quad +:\ \mathit{pcs}\ [5,6,7]
\end{aligned}
$$

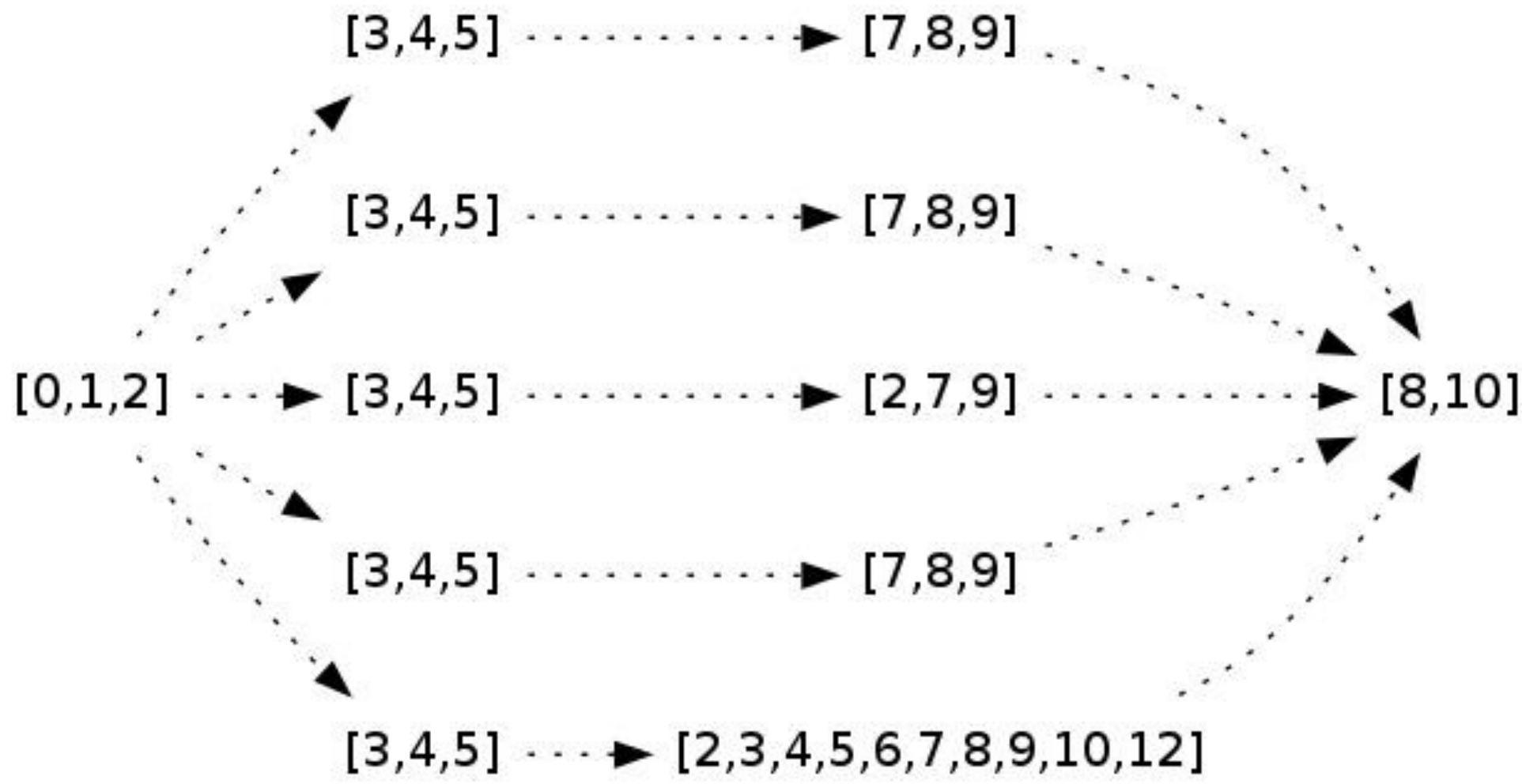
Cut and Inject Intuition



Helper code example

```
forte [pcs [0, 1, 2]] $
    init
    $<=: (5, transpose 3)
    =| [1] |= multiply 11
    =| [2] |= transpose 4
    =| [3] |= transpose 6 . multiply 5
    =| [4] |= invert
    =| [5] |= complement . transpose 8
    $>> 1
    $>=: (intersect, transpose 1)
```

Helper Intuitions



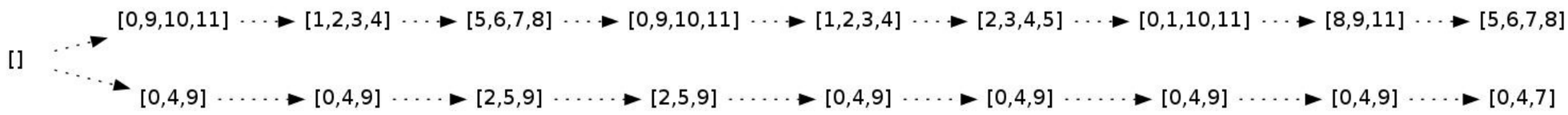
Forte Framework =

Forte DSL + Graph DSL

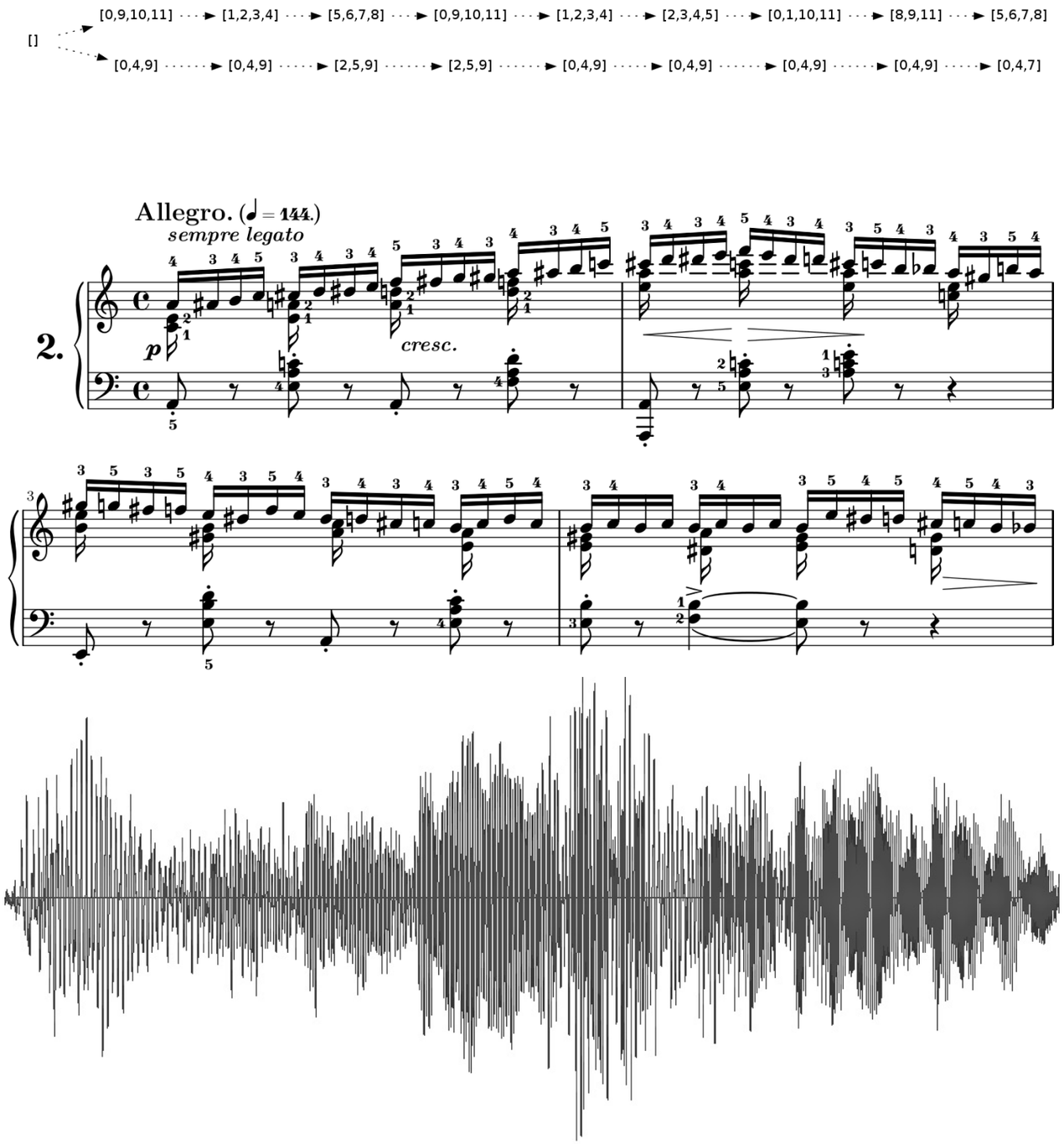
Getting real

$$
\begin{aligned}
&\mathit{forte}\ [\mathit{pcs}\ [\,]]\ \$\\
&\quad \mathit{init}' <: 2\\
&\qquad +|\ [1]\ |+\ \mathit{pcs}\ [0,9,10,11]\ \$+|\ [2]\ |+\ \mathit{pcs}\ [0,4,9]\\
&\quad \$=|\ [1]\ |=\ t\ 4\\
&\qquad =|\ [1]\ |=\ t\ 4\ \$=|\ [2]\ |=\ t\ 5\\
&\quad \$=|\ [1]\ |=\ t\ 4\\
&\qquad =|\ [1]\ |=\ t\ 4\ \$=|\ [2]\ |=\ t\ 7\\
&\quad \$=|\ [1]\ |=\ t\ 1\\
&\quad \$=|\ [1]\ |=\ t\ 8\\
&\quad \$=|\ [1]\ |=\ (\backslash\backslash\ \mathit{pcs}\ [10])\ .\ t\ 10\\
&\qquad =|\ [1]\ |=\ t\ 9\ .\ (\backslash/\ \mathit{pcs}\ [10])\ \$=|\ [2]\ |=\ t\ 4\ .\ i
\end{aligned}
$$

Final result …



… and with a little more work



Thank you!